

BACTERIOLOGICAL WATER QUALITY OF SIX MILE LAKE

by

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ONTARIO WATER RESOURCES COMMISSION

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Abstract

During the 1970 surveys, Six Mile Lake had bacterial levels less than the water quality criteria for total body contact recreation. The only exception to this situation was the higher fecal streptococcus levels at two stations, 11 and 40. The geometric mean bacterial levels can be summarized as follows:

Survey: August 29 - September 1, 1970

Total Coliform (TC)/100 ml	157 (approx. 400) *
Fecal Coliform (FC)/100 ml	5
Fecal Streptococcus (FS)/100 ml	3

* The approximate geometric mean bacterial level at the geographically distinct areas which include sections of Trans Canada Bay, Hungry Bay, Long Bay and Crooked Bay.

Some stations deviated from this average condition, but these deviations could be accounted for by changes in the natural environment.

Introduction

As part of the 1970 Recreational Lakes Program, a single intensive bacteriological survey was carried out on Six Mile Lake in the District Municipality of Muskoka. Six Mile Lake is a large irregularly shaped lake located beside the Trans Canada Highway 103. The lake is connected by dammed channels to the Severn River - Glouchester Pool system and ultimately to Georgian Bay. Directions of water flow in and out of the lake are at present uncertain.

Development on Six Mile Lake consists of a provincial park and marinas on the southern Trans Canada Bay. The remainder of the development is individual cottage units. There are no towns or villages on the lake.

Methods

On July 15, 1970, samples were taken at thirty-five surface stations and six depth stations. The data from this preliminary survey has not been included in this report or the statistical evaluation of the water quality of the lake

During the period of August 29 to September 1, 1970, daily bacteriological samples were taken at sixty-one surface stations and two (3D and 27D) depth stations on Six Mile Lake.

Surface stations were sampled within one meter of the water surface using sterile 250 ml autoclavable polycarbonate bottles. Depth stations were sampled using sterile 237 ml rubber air syringes and a modified "piggy-back" sampler. After taken, the samples were stored on ice until delivery to the nearby mobile laboratory. Within 4 to 8 hours, analysis of all samples was begun for the three bacterial parameters: total coliform (TC), fecal coliform (FC) and fecal streptococcus (FS). All analyses were by the membrane filtration method as set out in Standard Methods (1) except that MacConkey membrane broth was used for fecal coliforms.

The results from all analyses were organized as replicates representing the station during the survey period. All data was transformed to the natural logarithm (logarithm to the base e) and all further statistical evaluation was carried out on the transformed data. Initially, geometric means (the antilogarithm of the average of the logarithm data) were calculated for each station and each parameter. Then an analysis of variance or F-test (2) was carried out in order to group stations which were not significantly different one from the other.

The analysis of variance was first performed on all the stations for a given parameter and survey. If some of the stations proved to be significantly different, the data from these stations was removed to a separate grouping. The analysis of variance was then redone until no stations in the group were significantly different. All groups formed by the extraction of stations from the original group were similarly analyzed. A single geometric mean was then calculated for each homogeneous group of stations.

For convenience, all logarithms presented in the tables in this report are in the form of logarithms to the base 10.

Throughout the statistical evaluation of the data, all geometric mean bacterial levels were compared with the water quality criteria for total body contact recreational use as presented by the OWRC (4).

Results and Discussion

During the preliminary July 15, 1970 survey, individual bacterial counts at single stations can be summarized as follows:

	<u>Count</u>	
	<u>Maximum</u>	<u>Minimum</u>
TC / 100 ml	260	1
FC / 100 ml	464	1
FS / 100 ml	144	1.

Since the data from this preliminary survey are individual counts, any comparison with water quality criteria and any attempt to explicitly define the water quality from this data would be fallacious. However, it can be stated that at the time of the survey the bacterial levels in the lake were generally low and that some areas require further investigation.

The summary of the analysis of variance groupings of stations for the August 29 - September 1, 1970 survey is presented in Tables I, III and IV. The station locations and the geographic distribution of bacterial levels are presented in Figures 1 and 2.

Although the geometric mean TC levels were below the water quality criteria for total body contact recreation (1000 TC/100 ml), they present a complex geographic distribution (Figure 1).

The main body of the lake (Group 2) exclusive of the depth stations had a geometric mean TC level of 157/100 ml; while the bays, Trans Canada Bay (Group 1), Hungry Bay (Group 3), Long Bay (Group 4) and Crooked Bay (Group 5) had higher TC levels of about 400 TC/100 ml. These bay groupings of stations were not significantly different from the other (Table II) but are geographically distinct and therefore must be summarized separately.

The two depth stations, 3D and 27D, had geometric mean TC levels significantly lower than the rest of the lake at 35/100 ml and 17/100 ml respectively but not significantly different from one another ($t = 0.74$ df 6).

All geometric mean FC levels on Six Mile Lake were below the water quality criteria for total body contact recreation (100 FC/100 ml). Stations 51, 59 and 61 (Six Mile Lake Provincial Park) gave significantly higher FC levels at 43/100 ml, 33/100 ml and 28/100 ml respectively than the rest of the lake at 5 FC/100 ml. In addition, station 18 had a high FC count on Saturday, August 29.

The geometric mean FS level at most stations (3/100 ml) was below the water quality criteria for total body contact recreation (20 FS/100 ml). However, the FS levels at stations 6, 11, 17, 37 and 40 were significantly higher at 14, 25, 15, 18

and 23 FS/100 ml respectively. These higher FS levels are associated generally with the shallower weedy parts of the lake.

Except for the FS levels at stations 11 and 40, Six Mile Lake during the 1970 survey had bacterial levels less than the water quality criteria for total body contact recreation. The geometric mean bacterial levels can be summarized as follows:

Survey: August 29 - September 1, 1970

TC / 100 ml	157 (approx. 400) *
FC / 100 ml	5
FS / 100 ml	3.

* The approximate geometric mean bacterial level at the geographically distinct areas which include sections of Trans Canada Bay, Hungry Bay, Long Bay and Crooked Bay.

Some stations deviated from the average condition, but these deviations could be accounted for by changes in the natural environment and conditions.

References

- 1) "Standard Methods for the Examination of Water and Wastewater", twelfth edition 1965, APHA, AWWA, WPCF.
- 2) Sokal, R. R. and Rohlf, F. J., 1969. Biometry. The principles and practice of statistics in biological research. W. H. Freeman and Company, San Francisco, 776 pp.
- 3) Rohlf, F. J. and Sokal, R. R., 1969. Statistical Tables. W. H. Freeman and Company, San Francisco, 252 pp.
- 4) Ontario Water Resources Commission, June 1970. Guidelines and Criteria for Water Quality Management in Ontario.

TABLE I

Summary of Analysis of Variance
Grouping of Stations

Six Mile Lake, 1970

Survey: August 29 - September 1, 1970

Parameter: Total Coliform (TC) / 100 ml

Group: 1) Stations 1, 17, 18, 36, 37, 58, 59,
60 and 61.

F	0.75	df	8, 27
F (5%)	2.31		
	NSD		
log GM	2.5730		
S.E.	0.0392		
N	36.		
GM	374.		

Group: 2) Stations 2, 3, 7, 8, 9, 10, 15, 16,
19, 20, 23-30, 32, 33, 38, 39, 41,
42, 44, 47-52, 55, 56 and 57.

F	1.25	df	33, 102
F (5%)	1.55		
	NSD		
log GM	2.1954		
S.E.	0.0267		
N	136.		
GM	157.		

Table I - continued

Parameter: Total Coliform (TC) / 100 ml

Group: 3) Stations 21, 22 and 40.

F	0.01	df	2, 9
F (5%)	4.26		
	NSD		
log GM	2.5843		
S.E.	0.9965		
N	12.		
GM	384.		

Group: 4) Stations 4, 6, 53 and 54.

F	0.56	df	3, 12
F (5%)	3.49		
	NSD		
log GM	2.6028		
S.E.	0.0520		
N	16.		
GM	401.		

Group: 5) Stations 11-14, 45 and 46.

F	1.14	df	5, 17
F (5%)	2.91		
	NSD		
log GM	2.5965		
S.E.	0.0675		
N	23.		
GM	395.		

Table I - continued

Parameter: Total Coliform (TC) / 100 ml

Group: 6) Station 3D.

log GM	1.5455
S.E.	0.1226
N	4.
GM	35.

Group: 7) Station 27D.

log GM	1.2266
S.E.	0.4109
N	4.
GM	17.

Group: 8) Station 43.

log GM	2.6105
S.E.	0.0833
N	4.
GM	427.

TABLE II

Summary of t - test between Geographically Distinct
Analysis of Variance Groupings for Total Coliform/100 ml.

	Group			
	1	3	4	5
3	0.02 NSD df 46	-	-	-
4	0.44 NSD df 50	0.02 NSD df 26	-	-
5	0.32 NSD df 57	0.02 NSD df 33	0.07 NSD df 37	-
8	0.47 NSD df 38	0.03 NSD df 14	0.25 NSD df 18	0.20 NSD df 25

NSD = no significant difference at the .05 level.

TABLE III

Summary of Analysis of Variance
Grouping of Stations

Six Mile Lake, 1970

Survey: August 29 - September 1, 1970

Parameter: Fecal Coliform (FC) / 100 ml

Group: All stations.

F	1.56	df	58, 176
F (5%)	1.32		
	SD		

Group: 1) All stations except 51, 59 and 61.

F	1.15	df	55, 167
F (5%)	1.32		
	NSD		
log GM	0.6544		
S.E.	0.0383		
N	223.		
GM	5.		

Group: 2) Station 51.

log GM	1.6346
S.E.	0.0944
N	4.
GM	43.

Table III - continued

Parameter: Fecal Coliform (FC) / 100 ml

Group: 3) Station 59.

log GM	1.5121
S.E.	0.1632
N	4.
GM	33.

Group: 4) Station 61.

log GM	1.4398
S.E.	0.4810
N	4.
GM	28.

TABLE IV

Summary of Analysis of Variance
Grouping of Stations

Six Mile Lake, 1970

Survey: August 29 - September 1, 1970

Parameter: Fecal Streptococcus (FS) / 100 ml

Group: All Stations.

F	2.00	df	58, 176
F (5%)	1.32		
	SD		

Group: 1) All stations exdept 6, 11, 17, 37 and 40.

F	1.23	df	53, 161
F (5%)	1.35		
	NSD		
log GM	0.5188		
S.E.	0.0329		
N	215.		
GM	3.		

Group: 2) Station 6.

log GM	1.1584
S.E.	0.1704
N	4.
GM	14.

Table IV - continued

Parameter: Fecal Streptococcus (FS) / 100 ml

Group: 3) Station 11.

log GM	1.3975
S.E.	0.1816
N	4.
GM	25.

Group: 4) Station 17.

log GM	1.1896
S.E.	0.1993
N	4.
GM	15.

Group: 5) Station 37.

log GM	1.2617
S.E.	0.1860
N	4.
GM	18.

Group: 6) Station 40.

log GM	1.3577
S.E.	0.2349
N	4.
GM	23.

Appendix A

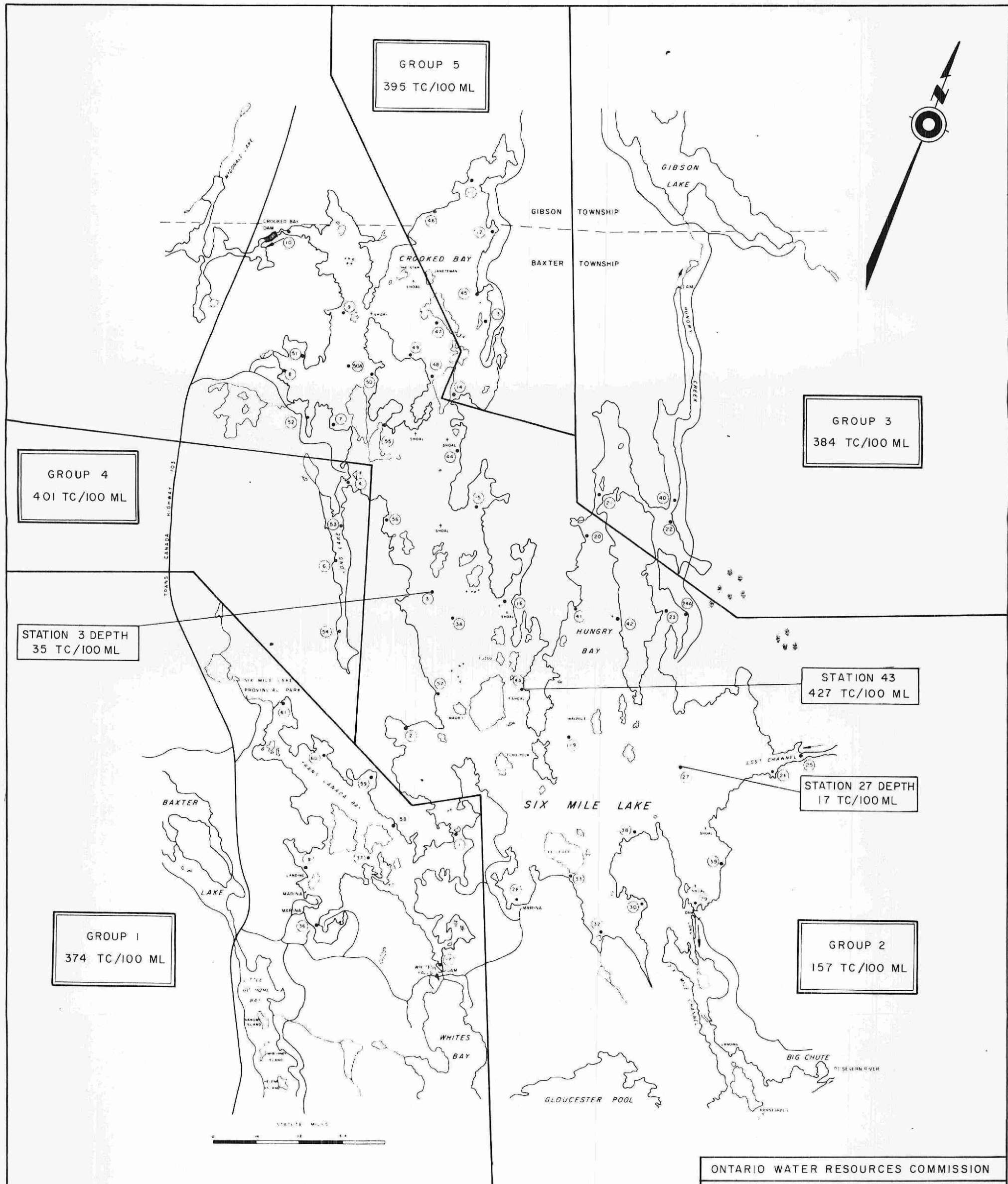
Explanation of Terms in Tables

- F - the calculated analysis of variance statistic on F ratio.
- df - degrees of freedom of the F ratio for "between group" and "within group" variation.
- F(5%) - the initial F ratio from a statistics table.
- If the calculated F is greater than the F(5%), a significant difference (SD) occurred between the groups in the analysis. If F is less than F(5%), no significant difference (NSD) occurred.
- log GM - the logarithm (base 10) of geometric mean for all groups in the analysis of variance when NSD occurred.
- S.E. - the standard error of the log GM where

$$S.E. = \frac{s}{\sqrt{n}} \text{ and } s = \text{standard deviation}$$

- N - the number of values in the mean.
- GM - the geometric mean of the bacterial level.
- t - the calculated test of significance or t-test to determine the between survey difference.
- If t for the number of degrees of freedom shown is greater than the critical t value, a significant difference (SD) occurs.

SIX MILE LAKE



GROUP 4
401 TC/100 ML

GROUP 5
395 TC/100 ML

GROUP 3
384 TC/100 ML

STATION 3 DEPTH
35 TC/100 ML

STATION 43
427 TC/100 ML

STATION 27 DEPTH
17 TC/100 ML

GROUP 1
374 TC/100 ML

GROUP 2
157 TC/100 ML

AUGUST 29 TO SEPTEMBER 1, 1970 SURVEY

GEOGRAPHICAL DISTRIBUTION OF TOTAL COLIFORM (TC)
GEOMETRIC MEAN BACTERIAL DENSITIES

LEGEND (37) • SAMPLING POINT → FLOW DIRECTION

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1970 RECREATIONAL LAKES PROGRAM
SIX MILE LAKE

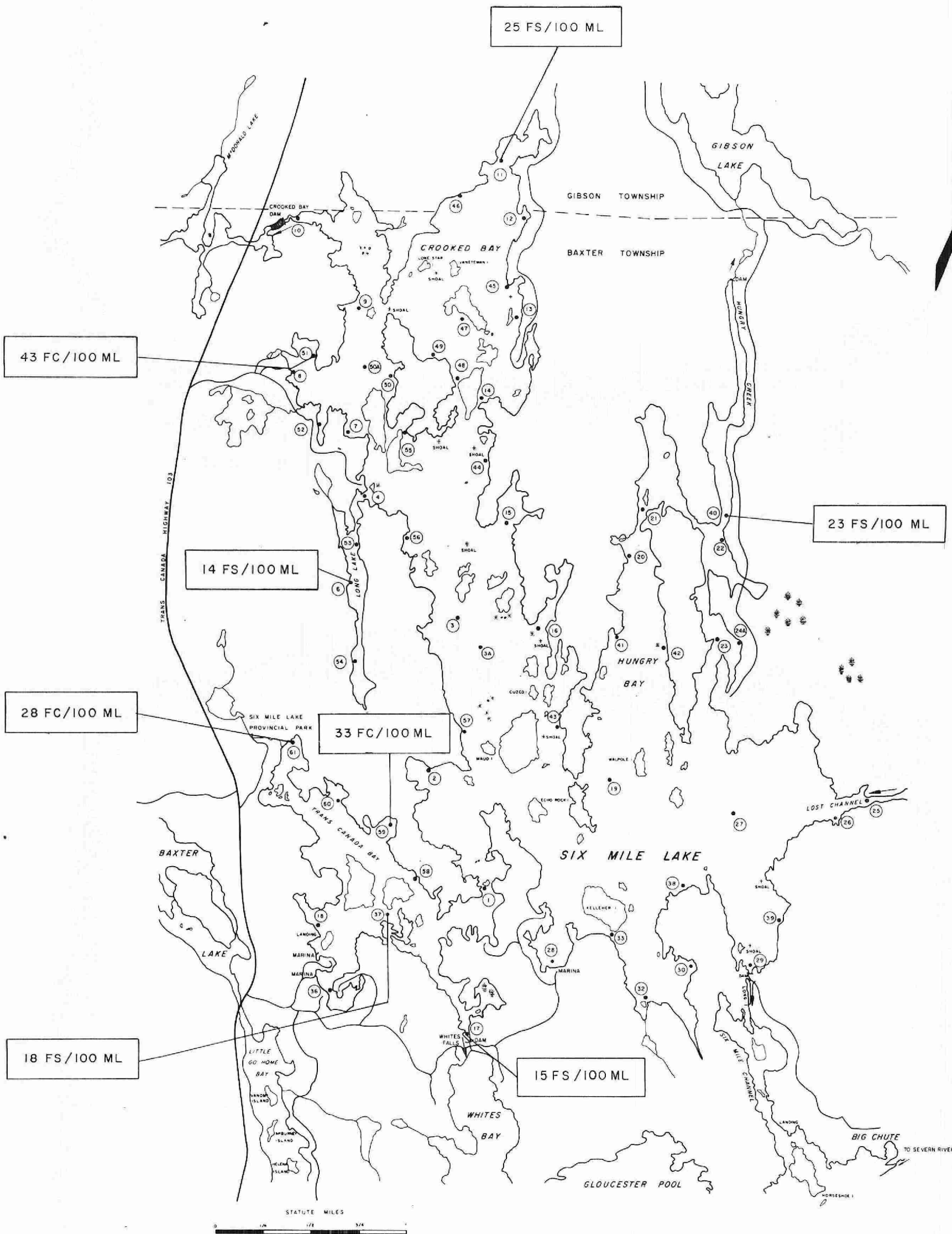
SCALE: AS NOTED

DRAWN BY: A.J.H.

DATE: NOVEMBER 1971

CHECKED BY: R.M.

DRAWING NO. 71-99-DE(A)



AUGUST 29 TO SEPTEMBER 1, 1970 SURVEY

OVERALL * GEOMETRIC MEAN BACTERIAL DENSITIES

5 FECAL COLIFORM (FC)/100 ML
3 FECAL STREPTOCOCCUS (FS)/100 ML

* EXCEPT WHERE OTHERWISE INDICATED ON THIS MAP, IN SUCH EXCEPTIONS, THE DIFFERING BACTERIAL DENSITY IS SHOWN AND THE REMAINING OVERALL DENSITIES APPLY.

LEGEND (25) ● SAMPLING POINT → FLOW DIRECTION

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1970 RECREATIONAL LAKES PROGRAM
SIX MILE LAKE

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Burger, A

Bacterial water

quality of Six Mile Lake anta

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